

PURIFICATION OF RECYCLED AND RENEWABLE ORGANIC MATERIAL

FIELD OF THE INVENTION

The present invention relates to a method of purifying recycled or renewable organic material, in particular removing silicon from recycled or renewable organic material comprising more than 1 ppm silicon as silicon compounds.

BACKGROUND OF THE INVENTION

In some cases recycled or renewable organic material contains high amounts of silicon (Si) as silicon compounds. Before catalytic processing of the recycled or renewable organic material these silicon impurities need to be removed from the material as silicon compounds are known catalyst poisons and should therefore be removed prior to hydrotreating to maximize the cycle length and profits of the hydrotreater.

In particular tall oil pitch (TOP) contains silicon impurities, most likely originating from anti-fouling agents used in upstream processing. Anti-fouling agents comprise e.g. polydimethylsiloxanes (PDMS), which are soluble in oil and are therefore difficult to remove from oil. Also, some other impurities can come from sand or dirt during wood collection. Removal of silicon impurities prior to hydrotreatment is required to avoid decreased lifetime of the catalyst in the unit. Conventional purification methods, such as filtration or bleaching, are not adequate to remove the silicon impurities effectively.

BRIEF DESCRIPTION OF THE INVENTION

An object of the present invention is thus to provide a method so as to overcome the above problems. The objects of the invention are achieved by a method which is characterized by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on the surprising realization that recycled or renewable organic material containing high amounts of silicon compounds may be purified by a method that leads to removal of Si from the recycled or renewable organic material as the recycled or renewable organic material is subjected to (b) heat treating the recycled or renewable organic material, preferably at 180 to 325°C, to form a heat treated recycled or renewable organic material, wherein at least part of silicon compounds present in the recycled or renewable organic material are converted to volatile silicon compounds, and thereafter (c) evaporating volatile silicon compounds from the heat treated recycled or renewable organic

material in one or more stages, preferably at 145 to 250°C, under reduced pressure, wherein at least part, preferably from 1 to 10 w%, of the heat treated recycled or renewable organic material evaporates.

The order of the individual process steps (b) and (c), and the conditions in heat treatment step (b) enable maximal silicon removal from the recycled or renewable organic material.

The method allows use of low quality recycled or renewable organic material feeds as a feedstock in hydrotreating, e.g. in processes producing high quality renewable fuels and/or chemicals.

10 BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 illustrates a first exemplary process flow of the present method; and

Figure 2 shows average Si removal efficiency of the flash evaporation for both with and without water addition.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a method of purifying a recycled or renewable organic material.

The term "recycled or renewable organic material" refers to organic material, i.e. material containing carbon, obtained 1) from a natural resource which replenishes to overcome recourse depletion caused by its usage and consumption or 2) from a raw or processed material that is recovered from a waste for reuse. The recycled or renewable organic material characteristically comprises aliphatic compounds having a carbon chain of from 4 to 30 carbon atoms, particularly from 12 to 22 carbon atoms. Typical examples of such aliphatic compounds are fatty acids or esters thereof, in particular wherein the fatty acids have an aliphatic chain of from 4 to 30 carbon atoms, more particularly from 12 to 22 carbon atoms. The recycled or renewable organic material typically comprises at least 50 wt% aliphatic compounds of the total weight of the recycled or renewable organic material.

Typically the recycled or renewable organic material refers to fats and/or oils of plant, microbial, algal, and/or animal origin. It also refers to any waste stream received from processing of such oils and/or fats. The recycled or

renewable organic material may be in an unprocessed form (e.g. animal fat), or a processed form (used cooking oil). The recycled or renewable organic material also refers to fossil waste-based oils and waste oils.

The term "plant based fats and oils" refers to fat and/or oils of plant origin i.e. oils that can originate directly from plants or can be byproducts from various industrial sectors, such as agriculture or forest industry.

Examples of plant based fats and oils of the present invention include, but are not limited to, sludge palm oil, rapeseed oil, canola oil, colza oil, sunflower oil, soybean oil, hemp oil, olive oil, linseed oil, cottonseed oil, mustard oil, palm oil, arachis oil, castor oil and coconut oil.

Other examples of plant based fats and oils include biocrudes and bio oils. Biocrudes and bio oils are produced from biomass, in particular from lignocellulosic biomass, with various liquefying methods, such as hydrothermal liquefaction, or pyrolysis, in particular fast pyrolysis.

The term "biocrude" refers to oils produced from biomass by employing hydrothermal liquefaction. The term "bio oil" refers to pyrolysis oils produced from biomass by employing pyrolysis. The term "biomass" refers to material derived from recently living organisms, which includes plants, animals and their byproducts. The term "lignocellulosic biomass" refers to biomass derived from plants or their byproducts. Lignocellulosic biomass is composed of carbohydrate polymers (cellulose, hemicellulose) and an aromatic polymer (lignin).

The term "pyrolysis" refers to thermal decomposition of materials at elevated temperatures in a non-oxidative atmosphere. The term "fast pyrolysis" refers to thermochemical decomposition of biomass through rapid heating in absence of oxygen. The term "hydrothermal liquefaction" (HTL) refers to a thermal depolymerization process used to convert wet biomass into crude-like oil under moderate temperature and high pressure.

Examples of bio oil and biocrude produced from lignocellulosic biomass, e.g. materials like forest harvesting residues or byproducts of a saw mill, are lignocellulosic pyrolysis liquid (LPL), produced by employing fast pyrolysis, and HTL-biocrude, produced by employing hydrothermal liquefaction.

Further examples of plant based fats and oils include crude tall oil (CTO), obtained as a by-product of the Kraft process (wood pulping), and its derivatives, such as tall oil pitch (TOP), crude fatty acid (CFA), tall oil fatty acid (TOFA) and distilled tall oil (DTO).

Crude tall oil comprises resin acids, fatty acids, and unsaponifiables. Resin acids are a mixture of organic acids derived from oxidation and polymerization reactions of terpenes. The main resin acid in crude tall oil is abietic acid but abietic derivatives and other acids, such as primaric acid are also found. Fatty acids are long chain monocarboxylic acids and are found in hardwoods and softwoods. The main fatty acids in crude tall oil are oleic, linoleic and palmitic acids. Unsaponifiables cannot be turned into soaps as they are neutral compounds which do not react with sodium hydroxide to form salts. They include sterols, higher alcohols and hydrocarbons. Sterols are steroids derivatives which also include a hydroxyl group.

The term "tall oil pitch (TOP)" refers to residual bottom fraction from crude tall oil (CTO) distillation processes. Tall oil pitch typically comprises from 34 to 51 wt% free acids, from 23 to 37 wt% esterified acids, and from 25 to 34 wt% unsaponifiable neutral compounds of the total weight of the tall oil pitch. The free acids are typically selected from a group consisting of dehydroabietic acid, abietic and other resin acids. The esterified acids are typically selected from a group consisting of oleic and linoleic acids. The unsaponifiables neutral compounds are typically selected from a group consisting of diterpene sterols, fatty alcohols, sterols, and dehydrated sterols.

The term "crude fatty acid (CFA)" refers to fatty acid-containing materials obtainable by purification (e.g., distillation under reduced pressure, extraction, and/or crystallization) of CTO. The term "tall oil fatty acid (TOFA)" refers to fatty acid rich fraction of crude tall oil (CTO) distillation processes. TOFA typically comprises mainly fatty acids, typically at least 80 wt% of the total weight of the TOFA. Typically TOFA comprises less than 10 wt% rosin acids.

The term "distilled tall oil (DTO)" refers to resin acid rich fraction of crude tall oil (CTO) distillation processes. DTO typically comprises mainly fatty acids, typically from 55 to 90 wt%, and rosin acids, typically from 10 to 40 wt% rosin acids, of the total weight of the DTO. Typically DTO comprises less than 10 wt% unsaponifiable neutral compounds of the total weight of the distilled tall oil.

The term "animal based fats and oils" refers to fats and/or oils of animal origin i.e. lipid materials derived from animals. Examples of animal based fats and oils include, but are not limited to, such as suet, tallow, blubber, lard, train oil, milk fat, fish oil, poultry oil and poultry fat.

The term "microbial oils" refers to triglycerides (lipids) produced by microbes.

The term "algal oils" refers to oils derived directly from algae.

The term "fossil waste-based oils" refers to oils produced from waste streams like waste plastics or end-life-tires. Examples of fossil waste-based oils include waste plastic pyrolysis oil (WPPO) and end-life-tire pyrolysis oil (ELTPO).

5 The term "waste oils" refers to any oils that, through contamination, have become unsuitable for their original purpose due to the presence of impurities or loss of original properties. Examples of waste oils are used lubricant oils (ULO), hydraulic oils, transformer oils or oils used in metal working.

10 In the present invention the recycled or renewable organic material is typically selected from a group consisting of plant based fats and oils, animal based fats and oils, fossil waste-based oils, waste oils, algal oils and microbial oils.

15 Particular examples of the recycled or renewable organic material of the present invention include, but are not limited to, animal based fats and oils, such as suet, tallow, blubber, lard, train oil, milk fat, fish oil, poultry oil, and poultry fat; plant based fats and oils, such as sludge palm oil, rapeseed oil, canola oil, colza oil, sunflower oil, soybean oil, hemp oil, olive oil, linseed oil, cottonseed oil, mustard oil, palm oil, arachis oil, castor oil, coconut oil, lignocellulosic pyrolysis liquid (LPL), HTL biocrude, crude tall oil (CTO), tall oil pitch (TOP), crude fatty acid (CFA), tall oil fatty acid (TOFA) and distilled tall oil (DTO); microbial oils; algal oils; recycled fats or various waste streams of the food industry, such as used cooking oil, yellow and brown greases; free fatty acids, any lipids containing phosphorous and/or metals, oils originating from yeast or mold products, recycled alimentary fats; starting materials produced by genetic engineering, and any mixtures of said feedstocks.

25 In an example is the present invention the recycled or renewable organic material is selected from a group consisting of crude tall oil (CTO), tall oil pitch (TOP), tall oil fatty acid (TOFA), crude fatty acid (CFA), tall oil fatty acid (TOFA) and distilled tall oil (DTO); more particularly the recycled or renewable organic material is crude tall oil (CTO) or tall oil pitch (TOP).

30 The recycled or renewable organic material to be treated by the present method contains high amounts of silicon compounds. The recycled or renewable organic material of the present invention comprises more than 1 ppm Si. In particular the recycled or renewable organic material of the present invention comprises more than 10 ppm Si, more particularly the recycled or renewable organic material of the present invention comprises more than 15 ppm Si, and even
35 more particularly the recycled or renewable organic material of the present in-

vention comprises more than 20 ppm Si.

The recycled or renewable organic material to be treated by the present method may also comprise further impurities e.g. impurities comprising phosphorus and/or metals in the form of phospholipids, soaps and/or salts. The impurities may for example be in the form of phosphates or sulfates, iron salts or organic salts, soaps or phospholipids. The metal impurities that may be present in the biomass-based lipid material are for example alkali metals or alkali earth metals, such as sodium or potassium salts, or magnesium or calcium salts, or any compounds of said metals.

Accordingly provided herein is a method of purifying a recycled or renewable organic material, wherein the recycled or renewable organic material comprises more than 1 ppm silicon as silicon compounds, comprising the steps of

(a) providing the recycled or renewable organic material;

(b) heat treating the recycled or renewable organic material to form a heat treated recycled or renewable organic material, wherein the at least part of silicon compounds present in the recycled or renewable organic material are converted to volatile silicon compounds, and

(c) evaporating volatile silicon compounds from the heat treated recycled or renewable organic material,

to obtain

(i) a vapor fraction comprising the major part of volatile silicon compounds, and (ii) a heat treated recycled or renewable organic material fraction comprising less silicon than the recycled or renewable organic material provided in step (a).

The heat treated recycled or renewable organic material fraction advantageously comprises less silicon than the recycled or renewable organic material provided in step (a), preferably less than 50%, more preferably less than 30% of the original silicon content of the recycled or renewable organic material provided in step (a).

The method optionally further comprises (d) hydrotreating the heat treated recycled or renewable organic material fraction in a presence of a hydrotreating catalyst to obtain purified recycled or renewable organic material.

The term "hydrotreating" refers to a chemical engineer process in which reaction of hydrogen is used to remove impurities, such as oxygen, sulfur, nitrogen, phosphorous, silicon and metals, especially as part of oil refining.

Hydrotreating can be performed in one or several steps in one or more reactor units or catalyst beds.

Step (d) is typically achieved under continuous hydrogen flow. For achieving optimal results the continuous hydrogen flow in step (d) preferably has
5 H₂/feed ratio from 500 to 2000 n-L/L, more preferably from 800 to 1400 n-L/L.

In step (d) hydrotreatment is advantageously performed at a temperature from 270 to 380°C, preferably from 275 to 360°C, more preferably from 300 to 350°C. Typically the pressure in step (d) is from 4 to 20 MPa.

The hydrotreating catalyst in step (d) preferably comprises at least one
10 component selected from IUPAC group 6, 8 or 10 of the Periodic Table. Preferably the hydrotreating catalyst in step (d) is a supported Pd, Pt, Ni, NiW, NiMo or a CoMo catalysts and the support is zeolite, zeolite-alumina, alumina and/or silica, preferably NiW/Al₂O₃, NiMo/Al₂O₃ or CoMo/Al₂O₃. In particular the hydrotreating catalyst is a sulfided NiW, NiMo or CoMo catalyst.

15 The time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is typically from 1 to 300 min, preferably from 5 to 240 min, more preferably from 30 to 90 min in step (d).

An applicable hydrotreatment step (d) provides a purified hydrotreated
20 ed recycled or renewable organic material. The purified hydrotreated recycled or renewable material advantageously comprises less than 20%, preferably less than 10%, more preferably less than 5%, of the original silicon content of the recycled or renewable organic material provided in step (a).

For achieving optimal results part of the hydrotreated recycled or re-
25 newable organic material may be recycled in step (d). Preferably the ratio of the fresh feed i.e. purified recycled or renewable organic material obtained in step (c) to the recycled hydrotreated recycled or renewable organic material is from 2:1 to 20:1.

In a particular example step (d) is accomplished by (d1) hydrodeoxygenating (HDO) the heat treated recycled or renewable organic material fraction.
30 This is preferably achieved in a presence of a HDO catalyst at a temperature from 290 to 350°C under pressure from 4 to 20 MPa and under continuous hydrogen flow.

The term "hydrodeoxygenation (HDO)" refers to removal of oxygen as
35 water by the means of molecular hydrogen under the influence of a (HDO) catalyst.

The HDO catalyst may for example be selected from a group consisting of NiMo-, CoMo-, NiW-catalysts and any mixtures thereof. Preferably the HDO catalyst is sulfided NiW, NiMo or CoMo catalyst.

Advantageously, the continuous hydrogen flow has H₂/feed ratio from
5 500 to 2000 n-L/L, preferably from 800 to 1400 n-L/L.

Preferably step (d1) is performed to obtain purified recycled or renewable organic material comprising less than 1 wt% oxygen.

In another example step (d) is accomplished by (d2) hydrodesulfurizing (HSD) the heat treated recycled or renewable organic material fraction. The
10 term "hydrodesulfurisation (HDS)" refers to removal of sulfur as hydrogensulfide by the means of molecular hydrogen under the influence of a (HDS) catalyst.

In another example step (d) is accomplished by (d3) hydrometallizing (HDM) the heat treated recycled or renewable organic material fraction. The term "hydrodemetallization (HDM)" refers to removal of metals by trapping them with
15 a (HDM) catalyst.

In another example step (d) is accomplished by (d4) hydrodenitrificating (HDN) the heat treated recycled or renewable organic material fraction. The term "hydrodenitrification (HDN)" refers to removal of nitrogen by the means of molecular hydrogen under the influence of a (HDN) catalyst.

20 In another example step (d) is accomplished by (d5) hydrodearomatizing (HDA) the heat treated recycled or renewable organic material fraction. The term "hydrodearomatisation (HDA)" refers to saturation or ring opening of aromatics by the means of molecular hydrogen under the influence of a (HDA) catalyst.

25 In step (b) the recycled or renewable organic material is heated to cause thermal reactions that disrupt silicon containing impurities comprised in the recycled or renewable organic material creating volatile silicon compounds material that can be subsequently removed from the heat treated recycled or renewable organic material. In particular polydimethylsiloxanes (PDMS) resulting
30 from anti-fouling agents degrade to volatile polydimethylcyclsiloxanes (PDMCS) under the process conditions.

In step (b) the water content in the feed, i.e. the recycled or renewable organic material may advantageously vary in from 200 to 5000 ppm. If the recycled or renewable organic material comprises more than 5000 ppm water, it may
35 be removed from the feed before step (b) by any suitable means known to a

skilled person for lowering the water content in the recycled or renewable organic material below 5000ppm.

The heat treatment of step (b) typically takes place at any temperature from 180 to 325°C. For achieving optimal results, step (b) is performed at 200 to 300°C, preferably at 240 to 280°C.

The time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is typically from 1 to 300 min, preferably from 5 to 90 min, more preferably from 20 to 40 min in step (b).

The pressure in the heat treatment in step (b) is typically from 500 to 5000 kPa, preferably from 800 to 2000 kPa.

The pressure range in step (b) is dictated by volatility of water and it is advantageous to keep the heat treatment pressure slightly higher than the balance pressure of water boiling in particular heat treatment temperature. Too low pressure may drive volatile components like water and fractions of fatty acids into gas phase. Carry over of organic volatiles is enhanced by presence of water or stripping.

After the heat treatment of step (b) the volatiles created due to the heat treatment and/or otherwise present in the heat treated recycled or renewable organic material are removed. Accordingly in step (c) the heat treated recycled or renewable organic material is subjected to evaporation of the volatile silicon compounds from the heat treated recycled or renewable organic material in one or more stages. In step (c) the evaporation is advantageously achieved at any temperature from 145 to 250°C, in particular at from 150°C to 225°C. For achieving optimal results, step (c) is performed at from 160°C to 200°C, preferably at from 160 to 180°C.

The reduced pressure in step (c) is such that evaporation of volatile Si compounds is achieved. Typically the pressure in step (c) is from 0.1 to 5 kPa, preferably from 0.1 to 3 kPa.

The evaporated mass should preferably be arranged to evaporation of 1 to 10 wt%, preferably from 1 to 8 wt%, more preferably from 1 to 5 wt%, even more preferably from 1 to 3 wt%, of the heat treated recycled or renewable organic material.

An applicable evaporation step (c) provides (i) a vapor fraction comprising the major part of volatile silicon compounds, and (ii) a heat treated recycled or renewable organic material fraction comprising less than 50%, preferably

less than 30%, of the original silicon content of the recycled or renewable organic material provided in step (a).

The evaporation in step (c) may be accomplished by any evaporation method found suitable by a skilled person for separation of the volatiles from the heat treated recycled or renewable organic material. Suitable examples include, but are not limited to, falling film evaporation, rising film evaporation, thin film evaporation and flash evaporation, for example. The evaporation may be accomplished in one or more stages. It is also to be understood that several evaporation methods, e.g. thin film evaporation and flash evaporation, may be combined. Preferable evaporation method of the present invention is one or multistage flash evaporation. Due to high pressure difference in flash vessel, less evaporation mass is needed in flash evaporation to provide better mass transfer as compared to thin film evaporation. For example, applying the same method and equipment as in a typical crude tall oil (CTO) thin film evaporation process for tall oil pitch (TOP) after heat treatment remarkably increases heat consumption as compared to flash evaporation.

The optimum temperature, pressure, evaporated mass, and how many flash stages to use depends on composition and quality of the recycled or renewable organic material and also on the heat treatment parameters (temperature, pressure and residence time) of step (b).

Furthermore, it is preferable to add water to the initial mixture of the heat treated recycled or renewable organic material. Adding a small percentage of water to the initial heat treated recycled or renewable organic material allows use of lower temperature and higher vacuum pressure while achieving the same level of Si removal than in normal evaporation. Even more importantly, there is less loss of volatile fatty acids, which reduces the amount of fatty acid waste to half compared to evaporation without water.

Accordingly in an example of the present invention water is added to the heat treated recycled or renewable organic material so that water content before evaporation step (c) is from 1 to 5 wt%, preferably from 1.5 to 4 wt% more preferably from 2 to 3 wt% of the total weight of the heat treated recycled or renewable organic material.

Figure 1 illustrates a first exemplary process flow of the present method.

Referring to Figure 1, a feed of recycled or renewable organic material, in particular tall oil pitch (TOP), is subjected to a step of heat treating the

recycled or renewable organic material as discussed herein for step (b). The heat treated feed of recycled or renewable organic material is then evaporated 30 as discussed herein for step (c) and a bottom containing a heat treated recycled or renewable organic material fraction 31 comprising less than 50%, preferably less than 30%, of the original silicon content of the recycled or renewable organic material provided in step (a), and a vapor fraction 32 comprising the major part of volatile silicon compounds is obtained. The heat treated recycled or renewable organic material fraction may then be subjected to hydrotreatment, in particular hydrodeoxygenation, as discussed herein for step (d) 40 to obtain recycled or renewable organic material comprising less than 20%, preferably less than 10%, more preferably less than 5%, of the original silicon content of the recycled or renewable organic material provided in step (a) 41. The purified recycled or renewable organic material 41 may then be subjected to catalytic upgrading 50.

After the recycled or renewable organic material has been purified in accordance with the present method, it may be subjected to further processing e.g. catalytic upgrading. Such catalytic upgrading processes include, but are not limited to, catalytic cracking, catalytic hydrocracking, thermo-catalytic cracking, catalytic hydrotreatment, fluid catalytic cracking, catalytic ketonization, and catalytic esterification. Such processes require the recycled or renewable organic material to be sufficiently pure and free from impurities that may otherwise hamper the catalytic process or poison the catalyst(s) present in the process.

Accordingly the present invention further provides a process for producing recycled or renewable hydrocarbons, comprising steps of (x) purifying the recycled or renewable organic material as discussed herein, and (y) subjecting the purified recycled or renewable organic material to an oil refinery conversion process, wherein the oil refinery conversion process comprises altering the molecular weight of the feed, such as hydrocracking, or steamcracking, removal of heteroatoms from the feed, such as thermal catalytic cracking, fluid catalytic cracking, or hydrotreating, in particular hydrodeoxygenating, or hydrodesulfurizing, altering the degree of saturation of the feed, such as hydrotreating, thermal catalytic cracking, or fluid catalytic cracking, rearranging the molecular structure of the feed, such as isomerizing, or any combination thereof to obtain at least one recycled or renewable hydrocarbon.

In a typical example of the present process the recycled or renewable hydrocarbon is a renewable traffic fuel or fuel component.

In an example of the present process, step (y) is hydrocracking. In such example, step (y) is preferably performed in a mild hydrocracking (MHC) refinery unit, in particular in a presence of a hydrocracking catalyst.

In another example of the present process, step (y) is steamcracking.
5 In such example step (y) is preferably performed in a steamcracking unit.

In yet another example of the present process, step (y) is isomerization. In such example, step (y) is preferably performed in an isomerization unit.

In yet another example of the present process, step (y) is hydrotreating. In such example, step (y) is preferably performed in a hydrotreating unit.
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In yet another example of the present process, step (y) is thermal catalytic cracking (TCC). In such example, step (y) is preferably performed in a thermal catalytic cracking unit.

In yet another example of the present process, step (y) is fluid catalytic cracking (FCC). In such example, step (y) is preferably performed in a fluid catalytic cracking unit.
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EXAMPLES

Example 1

Crude and heat treated tall oil pitch (TOP) were subjected to distillation under varied conditions. Yield and silicon content of obtained distillate and
20 bottom fractions are shown in Table 1 (reference) for crude TOP and in Table 2 for heat treated TOP.

Table 1

Crude TOP (Si=54ppm)				
	p (kPa)	T (°C)	Distillate	Bottom
Conditions	0.1	147		
Yield			4%	96%
Si /ppm			100	35
Conditions	1	194		
Yield			6%	94%
Si /ppm			230	35
Conditions	3	222		
Yield			6%	94%
Si /ppm			260	37
Conditions	5	236		
Yield			5%	95%
Si /ppm			280	36

Table 2

Heat-treated TOP (Si=25 ppm)				
	p (kPa)	T (°C)	Distillate	Bottom
Conditions	0.1	145		
Yield			4%	96%
Si /ppm			160	8
Conditions	1	193		
Yield			3%	97 %
Si /ppm			260	10
Conditions	3	220		
Yield			5%	95%
Si /ppm			440	11
Conditions	5	235		
Yield			5%	95%
Si /ppm			360	14

As can be seen from Table 1 and 2, silicon content in bottom fraction of heat-treated TOP is significantly lower than crude TOP's.

5 Example 2

Six tall oil pitch qualities were flash evaporated without water and with water (3%). Process conditions are shown in Table 3 (without water) and Table 4 (with water).

Table 3. Process conditions for the evaporation

Flash conditions	TOP1	TOP2	TOP4	TOP5	TOP6	TOPMIX
T run (°C)	172	184	190	228	218	190
P (kPa)	1	1	1	1	1	1
wt% (bottom)	93.9	91.5	93.3	93.7	93	93.5
wt% (heads)	6.1	8.5	6.7	6.3	7	6.5
wt% of fatty acids (heads)	5.5	6.8	6.2	5.9	6.8	6

10 **Table 4. Process conditions for the evaporation with water addition**

Flash conditions	TOP1	TOP2	TOP4	TOP5	TOP6	TOPMIX
Water added (%)	3	3	3	3	3	3
T run (°C)	160	160	160	160	160	160
P (mbar)	50	50	50	50	50	50
w% (bottom)	94.3	93.8	93.6	94.6	95.5	95.4
w% (heads)	5.7	6.2	6.4	5.4	4.5	4.6
w% of fatty acids (heads)	1.8	2.3	2.5	1.1	0.9	1

Table 5. Silicon contents after heat treatment (HT) and flash evaporation

Silicon content, ppm	TOP1	TOP2	TOP4	TOP5	TOP6	TOPMIX
After HT (Feed)	75	76	190	350	26	140
After Flash (without added water)	18	26	32	96	8.5	35
After Flash (3wt% water added)	15	27	32	100	8.6	34

The average Si-removal efficiency of the flash evaporation for both with and without water addition was 73% on average for all the 6 TOP qualities tested (Table 5). Even more importantly, there is less loss of volatile fatty acids, which reduces the amount of fatty acid waste to half compared to flashing without water (Table 4).

Example 3

Heat treated and flash evaporated TOP samples were hydrotreated (hydrodeoxygenated) in different temperatures. Other process conditions, pressure and weight hourly space velocity (WHSV), were kept constant. Pressure was 5000 kPa and WHSV was 0.95 1/h.

Table 6. Silicon contents of heat treated and flash evaporated TOP before and after HDO

Silicon content, ppm	T=291°C	T=320°C	T=333°C	T=350°C
After HT and flash (Feed)	43	43	43	43
After HDO	4	3.8	1.5	0.6

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The Si-removal efficiency of the hydrotreatment for heat treated and flash evaporated TOP increases when temperature is increased (Table 6).

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

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